Electrochemically Deposit ed Films of Bismuth Telluride and Related Materials for Thermoelectric Device Applicat ion..

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Bi_2Te_3 is a material that has been used for thermoelectric cooling, and this compound and related compositions are considered to be among the best materials available for such applications [1], Electrochemical deposition of compound semiconductors is a field that has grown considerably in recent years, primarily with applications to solar cells or optoelectronic devices [2]; application of this technique to fabrication of films of Bi_2Te_3 for thermoelectric devices follows logically from that work. Electrochemical deposition of Bi_2Te_3 has recently been demonstrated [3,4]. This paper presents a study of deposition conditions and substrates for fabrication of thin films of Bi_2Te_3 and related ternary solid solutions of $Bi_{(2)}Te_{(3-x)}Se_{(x)}$ and $Bi_{(2-x)}Sb_{(x)}Te_{(3)}$.

Bi_2Te_3 has been deposited potentiostatically from acidic, aqueous solutions of BiO^+ and $HTeO_2^+$ on a variety of substrates. We have studied the effect of electrolyte composition, and of deposition potential and current density on composition and grain size of Bi_2Te_3 films, as well as the effect of different substrate materials. It has been found that the best surface for Bi_2Te_3 deposition anti adhesion is noble metals such as Pt or Pd. These metals may be sputter or electrochemically deposited on a conducting or non-conducting substrate Fi lms have been deposited from HNO_3 and H_2SO_4/HCl solutions; different acids were used to avoid substrate dissolution. It was fount] that the best deposits were made from I 1 NO_3 solutions. Composition may be varied by changing the relative ratio of BiO^+ and 1 $HTeO_2^+$ in solution and by changing the deposition potential and/or current density during deposit ion. Grain size of the film is dependent on the growth rate, which is in turn, dependent on the current density during deposition. Films ranging in thickness from 500 Å. to several tens

Bi_2Te_3 may be deposited as Te-rich or Bi-rich films. This study has found that there is an effect of Bi/Te ratio in the solution, but that deposition potential is the major factor in controlling the composition in deposited films. Bi-rich films may be a combination of Bi_2Te_3 and BiTe. Te-rich films may contain some elemental Te. The films are polycrystalline with some preferential orientation. The degree of orientation appears to be related to grain size. It has also been shown that ternary compositions of BiTeSe and BiSbTe can also be deposited electrochemical I y from acidic solutions containing all constituents.

Electrodeposited films have been characterize by optical and electron microscopy including microprobe analysis and X-ray diff'ractometry. Characterization of electrical and thermoelectric properties of the films is in progress. Applications of these films will be discussed.

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